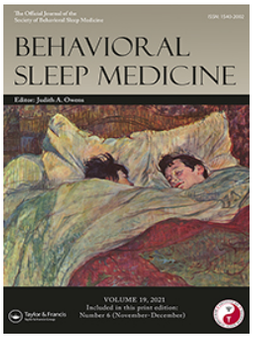

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Cross-Sectional and Longitudinal Associations between Subjective Sleep Difficulties and Self-Perceptions of Aging

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ABSTRACT

Background: Only one study has explored the associations of subjective sleep difficulties with self-perceptions of aging. It focused on a global indicator of self-perceptions of aging (subjective age) despite individuals reporting different experiences of aging in relation to different life domains. The concept of awareness of negative age-related change, capturing perceived losses across five domains (e.g., physical health, cognition), may be more appropriate when relating subjective sleep difficulties to self-perceptions of aging. We examined whether nine different indicators of subjective sleep difficulties predict levels of awareness of negative age-related change and subjective age, measured concurrently and one year later, while controlling for covariates (mood and daily function).

Participants/Methods: We used data from the PROTECT cohort study; 4,482 UK residents (mean age = 66.1; SD = 6.9) completed measures of awareness of age-related change, subjective age, mood, daily function, and subjective sleep difficulties.

Results: Based on linear regression analyses, poorer quality of sleep, lower alertness after awakening, satisfaction with sleep, depth of sleep, more frequent early awakening, difficulty falling asleep, more times awake during a night, fewer hours of sleep during the night and more hours of sleep during the day predicted higher awareness of negative age-related change at baseline and follow-up ($p < .001$). Associations were small in size. Associations between subjective sleep difficulties and subjective age were either negligible or statistically non-significant.

Conclusions: Although subjective sleep difficulties are one of the many factors associated with awareness of negative age-related change, addressing sleep difficulties, alongside negative mood, and poor daily functioning, may promote a small additional increase in positive self-perceptions of aging.

Aging individuals generally experience objective changes in sleep, including a decrease in sleep efficiency and an increase in sleep fragmentation, time taken to fall asleep, and daytime sleepiness (Klerman et al., 2004; Li et al., 2018; Yaffe et al., 2014; Yoon et al., 2003). These changes are due to age-related natural biological changes (e.g., reduced slow wave sleep) (Mander et al., 2017), but also to the poorer health that individuals tend to experience while aging (Ohayon et al., 2001; Stewart et al., 2006). Hence, two individuals of the same age can experience different degrees of sleep difficulties due to differences in their health (Public Health England, 2018). Poor sleep also impacts negatively on mental and physical health (Bubbico et al., 2019; Gadie et al., 2017; Sutter et al., 2012; Zee & Turek, 2006). Therefore, the associations of objective sleep difficulties with mental and physical health may be

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bidirectional. Good sleep may be particularly important for health maintenance in older age as in this stage of life individuals are more vulnerable to physical decline (United Nations, 2019; World Health Organization, 2020).

The term subjective sleep refers to individuals' rating of their sleep, which does not necessarily match information obtained through objective indicators of sleep (Kay et al., 2015; Mander et al., 2017; Westerlund et al., 2016). Subjective sleep is important as it captures those aspects of sleep (e.g., satisfaction with one's sleep) that cannot be assessed with objective measures (Gadie et al., 2017). Moreover, subjective sleep difficulties are common across adulthood and old age. A study found that 70% of US individuals aged 65 or over report difficulties with their sleep (Jaussent et al., 2011). Similarly, it has been estimated that 77% of adults in the UK do not wake up in the morning feeling well-rested (Mental Health Foundation, 2012; Morgan, 2016) and that older people report more subjective sleep difficulties than younger adults (Centers for Disease Control and Prevention, 2014; Mellor et al., 2014).

Like objective sleep difficulties, subjective sleep difficulties are related to poorer mental and physical health (Bernert et al., 2014; Kim et al., 2009; E. Lee et al., 2013; Lim et al., 2013; Meng-Yueh & Hsi-Chung, 2015; Schmutte et al., 2007). Moreover, individuals reporting subjective sleep difficulties show little engagement in health-related behaviors (e.g., physical activity; Holfeld & Ruthig, 2014), which are important for good sleep (Freburger et al., 2010) and mental and physical health (Fauth et al., 2012; Williams & Kemper, 2010). Subjective sleep difficulties may even play a role in the way in which individuals perceive themselves and their aging (M. Lee et al., 2009; Stephan et al., 2017).

Subjective age captures the age individuals feel they are, which can differ from one's chronological age (Barrett, 2003). The majority of middle-aged and older individuals feel younger than their chronological age, but there is a minority of people feeling their own age or older than their chronological age (Kotter-Grühn et al., 2016). One study found that those with more subjective sleep difficulties feel older than their chronological age (Stephan et al., 2017). This may be due to both an older subjective age and subjective sleep difficulties being linked to poorer mental and physical health (Bao et al., 2017; Sabatini et al., 2021d; Shirota et al., 2002; Westerhof et al., 2014). Indeed, those with an older subjective age are generally less engaged in health-related behaviors (Montepare, 2019) and have poorer physical, mental, and cognitive health compared to those reporting a younger subjective age (Choi & DiNitto, 2014; Sabatini et al., 2021c; Stephan et al., 2013, 2016a, 2016b, 2018).

Many studies linking subjective age to health outcomes used global assessments of subjective age (e.g., Choi & DiNitto, 2014), without acknowledging that the age individuals feel they are may vary in relation to different domains of their lives (e.g., social, cognitive, physical; Carstensen et al., 2011; Sabatini et al., 2021a, 2021c; Steverink et al., 2001; Voss et al., 2018). Conversely, the multidimensional concept of awareness of age-related change (Diehl & Wahl, 2010) captures perceived changes across five domains (physical health, cognition, interpersonal relationships, socio-cognitive and socio-emotional functioning, lifestyle) that are generally associated with sleep difficulties (Bubbico et al., 2019; Foley et al., 2010; Gadie et al., 2017; Goldman et al., 2007; Mander et al., 2017; Mental Health Foundation, 2012; Pilcher et al., 1997; Sutter et al., 2012).

More specifically awareness of age-related change captures a person's state of awareness that their behavior, level of performance, and/or way of experiencing life has changed due to their increased age (Diehl & Wahl, 2010). The heuristic framework of awareness of age-related change places the concept in relation to variables that may act as antecedents of awareness of age-related change (e.g., personal goals, life limitations, and current life events), variables involved in the mental process of awareness of age-related change (e.g., self-regulatory behavior), and outcomes of awareness of age-related change (health and life engagement). Hence, awareness of age-related change is conceived as a type of self-knowledge that may be a prerequisite for taking active control over one's aging process.

As Stephan et al. (2017) provides the only available evidence supporting the association of subjective sleep difficulties with self-perceptions of aging and relied on a global measure of subjective age, the current study aims to advance understanding of the topic by linking subjective sleep difficulties with scores on a measure of awareness of age-related changes (Brothers et al., 2019;

Kaspar et al., 2019). Second, this study estimates and compares the size of the associations of subjective sleep difficulties with awareness of age-related change and subjective age. Third, whereas Stephan et al. (2017) showed that self-perceptions of aging impact on subjective sleep difficulties, it may well be that the experience of sleep difficulties influences subjective age (Sabatini et al., 2021c). We, therefore, explore whether subjective sleep difficulties predict self-perceptions of aging while controlling for other well-known predictors of self-perceptions of aging such as mood (i.e. depression and anxiety) and daily functions (Bergland et al., 2014; Sabatini et al., 2020a).

Fourth, differently from Stephan et al. (2017) who calculated an index of severity of subjective sleep difficulties based on four indicators of subjective sleep difficulties, we explore the individual associations of self-perceptions of aging with nine indicators of subjective sleep difficulties. This is important because age-related changes in sleep are multifaceted and, therefore, the strength of the association with self-perceptions of aging may vary across different indicators of sleep difficulties (Gadie et al., 2017).

Overall, this study is a preliminary effort to explore in a large sample of UK individuals aged 50 and over the cross-sectional and longitudinal associations of a wide range of subjective sleep difficulties with awareness of age-related change and subjective age. We hypothesize that individuals reporting more severe subjective sleep difficulties experience more awareness of negative age-related change and an older or less young subjective age both concurrently and a year later. We also hypothesize that the strength of associations of subjective sleep difficulties with self-perceptions of aging is greater for awareness of negative age-related change than for subjective age. As many individuals hold negative views of aging (Levy, 2017) and awareness of age-related change is amenable to change (Brothers & Diehl, 2017), identifying predictors of self-perception of aging, such as perceived sleep difficulties, may suggest ways of promoting more positive experiences of aging.

Method

Study design and participants

This study uses data for 4,482 participants collected through the ongoing PROTECT study (https://www.protectstudy.org.uk) in 2019 (baseline for the current study sample) and 2020 (one-year follow-up for the current study sample). The PROTECT cohort study started in 2015. Further information on study design and participants is provided in Supplementary text 1. The awareness of age-related change, subjective age, and sleep measures were completed by 7,258 participants in 2019 and awareness of age-related change and subjective age measures were completed by 4,530 individuals in 2020. Of these 4,530 potential participants, 48 were excluded from study analyses due to missing data in measures assessing depression and anxiety. In total, therefore, 2,776 participants who provided baseline data were not included in the analyses. Participants excluded from study analyses were similar to the analysis sample in terms of mean age, proportion of women, level of education, symptoms of depression and anxiety and subjective sleep difficulties; see Table 1.

Measures

To assess awareness of negative age-related change at baseline and one-year follow-up we used the five-item subscale of the AARC-10 SF (Kaspar et al., 2019), see Supplementary Table S1. Respondents rate how much each item applies to them on a five-point scale (1 – not at all, 5 – very much). Higher scores (range: 5–25) indicate higher perceived losses. This scale has good internal consistency for the UK population, with a Cronbach's α value of 0.80 (Sabatini et al., 2020b).

To assess subjective age at baseline and one-year follow-up we used the question *"Many people feel older or younger than they actually are. Fill in the age (in years) that you feel most of the time:"* (Barrett, 2003). To obtain an indicator of the extent to which subjective age is younger or older than chronological age, a percentage discrepancy score was calculated by subtracting participants'

Table 1. Descriptive statistics of demographic variables and main study variables.

Variables	Study sample (N = 4,482)	Participants who did not complete the follow-up (N = 2,776)
Age at baseline in years, Mean (SD; range)	66.1 (6.9; 53.1 to 95.9)	65.6 (7.2; 53.0 to 92.9)
Sex (Women; n (%))	3,466 (77.3)	2,175 (78.4)
Education, n (%)	1,167 (26.0)	689 (24.8)
Below university	3,315 (74.0)	2,087 (75.2)
University		
Awareness of negative age-related change at baseline, Mean (SD; range)	9.8 (3.2; 5 to 25)	9.9 (3.3; 5 to 25)
Awareness of negative age-related change at follow-up, Mean (SD; range)	10.1 (3.4; 5 to 25)	Not applicable
Awareness of negative age-related change at baseline – physical domain	2.77 (1.07; 1 to 5)	2.81 (1.06; 1 to 5)
Awareness of negative age-related change at baseline – cognitive domain	2.03 (.86; 1 to 5)	2.07 (0.88; 1 to 5)
Awareness of negative age-related change at baseline – interpersonal relations domain	1.44 (.70; 1 to 5)	1.47 (0.74; 1 to 5)
Awareness of negative age-related change at baseline – socio-cognitive socio-emotional domain	1.63 (.81; 1 to 5)	1.67 (0.84; 1 to 5)
Awareness of negative age-related change at baseline – lifestyle domain	1.89 (.86; 1 to 5)	1.92 (0.89; 1 to 5)
Subjective age discrepancy at baseline, Mean (SD; range)	0.17 (0.1; −0.48 to 0.99)	0.17 (0.1; −0.67 to 0.99)
Subjective age discrepancy at follow-up, Mean (SD; range)	0.17 (0.1; −0.49 to 0.89)	Not applicable
IADL at baseline, Mean (SD; range)	0.14 (0.7; 0 to 12)	0.17 (0.8; 0 to 11)
Depressive symptoms at baseline, Mean (SD; range)	11.4 (2.8; 9 to 30)	11.4 (3.3; 5 to 32)
Anxiety symptoms at baseline, Mean (SD; range)	8.4 (2.4; 7 to 28)	8.4 (2.7; 2 to 27)
Quality of sleep, Mean (SD; range)	3.9 (1.0; 1 to 6)	3.9 (1.0; 1 to 6)
Quality of sleep (n, (%))	104 (2.3)	60 (2.2)
Very badly	271 (6.1)	162 (5.8)
Badly	983 (21.9)	636 (22.9)
Fairly badly	2,064 (46.1)	1,293 (46.6)
Fairly well	800 (17.9)	477 (17.2)
Well	260 (5.8)	148 (5.3)
Very well		
Alertness after awakening, Mean (SD; range)	3.8 (1.0; 1 to 6)	3.7 (1.0; 1 to 6)
Alertness after awakening (n, (%))	82 (1.8)	53 (1.9)
Very drowsy	373 (8.3)	253 (9.1)
Moderately drowsy	1,128 (25.2)	742 (26.7)
Slightly drowsy	1,902 (42.4)	1,168 (42.1)
Fairly clearheaded	886 (19.8)	508 (18.3)
Alert	111 (2.5)	52 (1.9)
Very alert		
Satisfaction with sleep, Mean (SD; range)	3.3 (1.1; 1 to 5)	3.3 (1.1; 1 to 5)
Satisfaction with sleep (n (%))	352 (7.9)	197 (7.1)
Very unsatisfied	719 (16.0)	475 (17.1)
Moderately unsatisfied	1,089 (24.3)	700 (25.2)
Slightly unsatisfied	1,859 (41.5)	1,136 (40.9)
Fairly satisfied	463 (10.3)	268 (9.7)
Completely satisfied		
Early awakening (Yes; n (%))	1,974 (44.0)	1,215 (43.8)
Difficulty falling asleep, Mean (SD; range)	1.41 (0.6; 1 to 4)	1.44 (0.6)
Difficulty falling asleep (n (%))	2,918 (65.1)	1,749 (63.0)
None or very little	1,327 (29.6)	873 (31.5)
Some	199 (4.4)	124(4.5)
A lot	38 (0.9)	30 (1.1)
Extreme difficulty		

(*Continued*)

Table 1. (Continued).

Variables	Study sample (N = 4,482)	Participants who did not complete the follow-up (N = 2,776)
Depth of sleep, Mean (SD; range)	3.5 (1.0; 1 to 6)	3.5 (1.0; 1 to 6)
Depth of sleep (n (%))	194 (4.3)	109(3.9)
Very light	365 (8.1)	232 (8.4)
Light	1,387 (31.0)	912 (32.9)
Fairly light	1,998 (44.6)	1,199 (43.2)
Fairly deep	491 (11.0)	298 (10.7)
Deep	47 (1.1)	26 (0.9)
Very deep		
Times awake during a night, (n (%))	147 (3.3)	111 (4.0)
One	1,415 (31.6)	843 (30.4)
Two	1,542 (34.4)	968 (34.9)
Three	1,378 (30.8)	854 (30.8)
Four or more		
Hours of sleep during the night; (n (%))	475 (10.6)	303 (10.9)
Zero to five	3,893 (86.9)	2,387 (86.0)
Six to eight	114 (2.5)	86 (3.1)
Nine and above		
Hours of sleep during the day; (n (%))	4,081 (91.1)	1,476 (89.3)
Zero	317 (7.1)	241 (8.7)
One or two	84 (1.9)	56 (2.0)
Three or more		

IADL – Instrumental activities of daily living. Depressive symptoms – Participants' score on the Patient Health Questionnaire-9. Anxiety symptoms – Participants' score on the GAD-7.

subjective age from their chronological age, dividing this difference by participants' chronological age and multiplying by 100. A positive value indicates a younger subjective age, whereas a negative value indicates an older subjective age. Values further away from zero indicate a greater discrepancy between the age individuals feel they are and their chronological age.

To assess subjective sleep difficulties we used the St Mary's Sleep Scale (Ellis et al., 1981). The nine items capture quality of sleep (1 – Very badly, 6 – Very well), alertness after awakening (1 – Very drowsy, 6 – Very alert), satisfaction with sleep (1 – Very unsatisfied, 5 – Completely satisfied), early awakening (0 – No, 1 – Yes), difficulty falling asleep (1 – None or very little, 4 – Extreme difficulty), depth of sleep (1 – Very light, 6 – Very deep), average number of times awake during a night (recategorized into: 1 – One, 2 – Two, 3 – Three, 4 – Four or more), average number of hours of sleep at night (recategorized into: 1 – Zero to five, 2 – Six to wight, 3 – Nine and above), and hours of sleep during the day over the last month (recategorized into: 1 – Zero, 2 – One or two, 3 – Three or more). In the normative sample, test-retest correlations for the St Mary's Sleep Scale have been derived using Kendall's Tau nonparametric correlation coefficient; each item was deemed reliable (range for Tau values: 0.70–0.96).

Participants provided their age, sex, and educational achievement (*below university* – secondary education or post-secondary education; *university* – vocational qualifications, undergraduate degrees, post-graduate degrees, or doctorates).

The Generalized Anxiety Disorder-7 (GAD-7; Spitzer et al., 2006) was used to assess anxiety. For each item, response options range from 1 (not at all) to 4 (nearly every day). Higher scores indicate greater anxiety (range: 7–28). In this study, Cronbach's α for the GAD-7 was 0.85. The Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001) was used to assess depression. For each item response options range from 1 (not at all) to 4 (nearly every day). Higher scores indicate greater depression (range: 9–36). In this study, Cronbach's α for the PHQ was 0.75. To assess daily functioning we used Lawton's Instrumental Activities of Daily Living Scale (IADL; Lawton & Brody, 1969). For each binary item, the response options are "no difficulty" (1) and "great difficulty" (2). Higher total scores,

Table 2. Linear regressions with participants' score on each of the nine indicators of sleep as the predictor and awareness of negative age-related change at baseline as the outcome: Unadjusted and adjusted unstandardized and standardized regression coefficients and 95% confidence intervals.

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Quality of sleep	Model 1: Unadjusted	Very badly	Reference category	Reference category	<.001	3.0%
		Badly	-1.70 (−2.41 to −0.99)	-0.12 (−0.17 to −0.07)		
		Fairly badly	-2.0 (−2.64 to −1.37)	-0.26 (−0.34 to −0.18)		
		Fairly well	-2.69 (−3.31 to −2.07)	-0.42 (−0.51 to −0.32)		
		Well	-3.20 (−3.84 to −2.56)	-0.38 (−0.46 to −0.31)		
		Very well	-3.34 (−4.06 to −2.63)	-0.24 (−0.30 to −0.19)		
	Model 2: Adjusted for demographic and health-related variables	Very badly	Reference category	Reference category	<.001	1.0%
		Badly	-1.13 (−1.77 to −0.47)	-0.08 (−0.12 to −0.04)		
		Fairly badly	-1.07 (−1.66 to −0.48)	-0.14 (−0.21 to −0.06)		
		Fairly well	-1.39 (−1.97 to −0.80)	-0.22 (−0.31 to −0.13)		
		Well	-1.73 (−2.34 to −1.12)	-0.21 (−0.28 to −0.13)		
		Very well	-1.81 (−2.48 to −1.13)	-0.13 (−0.18 to −0.08)		

(*Continued*)

Table 2. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Alertness after awakening	Model 1: Unadjusted	Very drowsy	Reference category	Reference category	<.001	8.0%
		Moderately drowsy	-1.33 (−2.07 to −0.60)	-0.12 (−0.18 to −0.05)		
		Slightly drowsy	-2.42 (−3.11 to −1.73)	-0.33 (−0.42 to −0.24)		
		Fairly clearheaded	-3.25 (−3.93 to −2.56)	-0.50 (−0.60 to −0.40)		
		Alert	-4.04 (−3.73 to −3.34)	-0.50 (−0.59 to −0.42)		
		Very alert	-4.84 (−5.72 to −3.96)	-0.23 (−0.28 to −0.19)		
	Model 2: Adjusted for demographic and health-related variables	Very drowsy	Reference category	Reference category	<.001	4.0%
		Moderately drowsy	-0.66 (−1.34 to 0.02)	-0.06 (−0.12 to 0.001)		
		Slightly drowsy	-1.43 (−2.07 to −0.79)	-0.19 (−0.28 to −0.11)		
		Fairly clearheaded	-2.09 (−2.73 to −1.45)	-0.32 (−0.42 to −0.22)		
		Alert	-2.71 (−3.37 to −2.05)	-0.34 (−0.42 to −0.26)		
		Very alert	-3.30 (−4.12 to −2.47)	-0.16 (−0.20 to −0.12)		
Satisfaction with sleep	Model 1: Unadjusted	Very unsatisfied	Reference category	Reference category	<.001	3.0%
		Moderately unsatisfied	-0.68 (−1.09 to −0.28)	-0.08 (−0.12 to −0.03)		
		Slightly unsatisfied	-1.10 (−1.48 to −0.72)	-0.15 (−0.20 to −0.10)		
		Fairly satisfied	-1.58 (−1.94 to −1.22)	-0.24 (−0.30 to −0.19)		
		Completely satisfied	-2.34 (−2.78 to −1.90)	-0.22 (−0.26 to −0.18)		
	Model 2: Adjusted for demographic and health-related variables	Very unsatisfied	Reference category	Reference category	<.001	1.0%
		Moderately unsatisfied	-0.23 (−0.60 to 0.14)	-0.03 (−0.07 to 0.02)		
		Slightly unsatisfied	-0.40 (−0.75 to −0.05)	-0.05 (−0.10 to −0.01)		
		Fairly satisfied	-0.63 (−0.97 to −0.29)	-0.10 (−0.15 to −0.05)		
		Completely satisfied	-1.28 (−1.70 to −0.86)	-0.12 (−0.16 to −0.08)		

(*Continued*)

Table 2. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Early awakening	Model 1: Unadjusted	Yes	0.79 (0.60 to 0.98)	0.12 (0.09 to 0.15)	<.001	2.0%
	Model 2: Adjusted for demographic and health-related variables	Yes	0.34 (0.16 to 0.51)	0.05 (0.02 to 0.08)	<.001	0.2%
Difficulty falling asleep	Model 1: Unadjusted	None or very little	Reference category	Reference category	<.001	2.0%
		Some	0.56 (0.35 to 0.77)	0.08 (0.05 to 0.11)		
		A lot	2.03 (1.57 to 2.48)	0.13 (0.10 to 0.16)		
		Extreme difficulty	1.94 (0.93 to 2.96)	0.06 (0.03 to 0.08)		
	Model 2: Adjusted for demographic and health-related variables	None or very little	Reference category	Reference category	<.001	1.0%
		Some	0.33 (0.14 to 0.52)	0.05 (0.02 to 0.07)		
		A lot	1.24 (0.82 to 1.66)	0.08 (0.05 to 0.11)		
		Extreme difficulty	0.36 (−0.58 to 1.29)	0.01 (−0.02 to 0.04)		
Depth of sleep	Model 1: Unadjusted	Very light	Reference category	Reference category	<.001	1.0%
		Light	-0.43 (−0.99 to 0.12)	-0.04 (−0.08 to 0.01)		
		Fairly light	-0.99 (−1.47 to −0.51)	-0.14 (−0.21 to −0.07)		
		Fairly deep	-1.17 (−1.64 to −0.70)	-0.18 (−0.25 to −0.11)		
		Deep	-1.65 (−2.18 to −1.12)	-0.16 (−0.21 to −0.11)		
		Very deep	-1.15 (−2.17 to −0.13)	-0.04 (−0.07 to −0.004)		
	Model 2: Adjusted for demographic and health-related variables	Very light	Reference category	Reference category	.080	0.1%
		Light	0.23 (−0.27 to 0.74)	0.02 (−0.02 to 0.06)		
		Fairly light	-0.18 (−0.62 to 0.27)	-0.03 (−0.09 to 0.04)		
		Fairly deep	-0.08 (−0.51 to 0.36)	-0.01 (−0.08 to 0.06)		
		Deep	-0.41 (−0.90 to 0.09)	-0.04 (−0.09 to 0.01)		
		Very deep	0.18 (−0.74 to 1.11)	0.01 (−0.02 to 0.04)		
Times awake during a night	Model 1: Unadjusted	One	Reference category	Reference category	<.001	1.0%
		Two	0.17 (−0.37 to 0.71)	0.02 (−0.05 to 0.10)		
		Three	0.67 (0.13 to 1.21)	0.10 (0.02 to 0.18)		
		Four or more	1.10 (0.52 to 1.60)	0.15 (0.07 to 0.23)		
	Model 2: Adjusted for demographic and health-related variables	One	Reference category	Reference category	.003	0.2%
		Two	-0.05 (−0.54 to 0.44)	-0.01 (−0.08 to 0.06)		
		Three	0.15 (−0.34 to 0.64)	0.02 (−0.05 to 0.09)		
		Four or more	0.29 (−0.21 to 0.78)	0.04 (−0.03 to 0.11)		

(*Continued*)

Table 2. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Hours of sleep during the night	Model 1: Unadjusted	Zero to five	Reference category	Reference category	<.001	2.0%
		Six to eight	-1.37 (−1.67 to −1.06)	-0.14 (−0.18 to −0.11)		
		Nine and above	-0.83 (−1.49 to −0.19)	-0.04 (−0.07 to −0.01)		
	Model 2: Adjusted for demographic and health-related variables	Zero to five	Reference category	Reference category	.021	0.1%
		Six to eight	-0.45 (−0.74 to −0.17)	-0.05 (−0.08 to −0.02)		
		Nine and above	-0.19 (−0.78 to 0.41)	-0.01 (−0.04 to 0.02)		
Hours of sleep during the day	Model 1: Unadjusted	Zero	Reference category	Reference category	<.001	1.0%
		One or two	1.82 (1.46 to 2.18)	0.15 (0.12 to 0.17)		
		Three or more	0.58 (−0.11 to 1.26)	0.02 (−0.01 to 0.05)		
	Model 2: Adjusted for demographic and health-related variables	Zero	Reference category	Reference category	<.001	0.4%
		One or two	1.06 (0.73 to 1.39)	0.09 (0.06 to 0.11)		
		Three or more	0.34 (−0.28 to 0.96)	0.01 (−0.01 to 0.04)		

Demographic variables included in the model as covariates are age, sex, and education level. Health-related variables included in the model as covariates are depressive and anxiety symptoms and daily function. B – Regression coefficient. SE – Standard error. β – Standardized regression coefficient. 95% CI – 95% confidence interval.

Table 3. Linear regressions with participants' score on each of the nine indicators of sleep as the predictor and awareness of negative age-related change at follow-up as the outcome: Unadjusted and adjusted unstandardized and standardized regression coefficients and 95% confidence intervals.

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Quality of sleep	Model 1: Unadjusted	Very badly	Reference category	Reference category	<.001	2.0%
		Badly	-1.42 (−2.17 to −0.67)	-0.10 (−0.15 to −0.05)		
		Fairly badly	-1.68 (−2.35 to −1.01)	-0.21 (−0.29 to −0.12)		
		Fairly well	-2.38 (−3.03 to −1.72)	-0.36 (−0.45 to −0.26)		
		Well	-2.74 (−3.42 to −2.06)	-0.31 (−0.39 to −0.23)		
		Very well	-2.84 (−3.60 to −2.08)	-0.20 (−0.25 to −0.15)		
	Model 2: Adjusted for demographic, health-related variables	Very badly	Reference category	Reference category	<.001	0.03%
		Badly	-0.84 (−1.53 to −0.16)	-0.06 (−0.11 to −0.01)		
		Fairly badly	-0.72 (−1.34 to −0.10)	-0.09 (−0.16 to −0.01)		
		Fairly well	-1.03 (−1.64 to −0.42)	-0.15 (−0.24 to −0.06)		
		Well	-1.22 (−1.85 to −0.58)	-0.14 (−0.21 to −0.07)		
		Very well	-1.25 (−1.96 to −0.54)	-0.09 (−0.14 to −0.04)		

(*Continued*)

Table 3. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Alertness after awakening	Model 1: Unadjusted	Very drowsy	Reference category	Reference category	<.001	8.0%
		Moderately drowsy	-0.95 (−1.73 to −0.18)	-0.08 (−0.14 to −0.01)		
		Slightly drowsy	-2.15 (−2.87 to −1.42)	-0.28 (−0.37 to −0.18)		
		Fairly clearheaded	-2.95 (−3.66 to −2.23)	-0.43 (−0.54 to −0.33)		
		Alert	-3.88 (−4.61 to −3.14)	-0.46 (−0.54 to −0.37)		
		Very alert	-4.90 (−5.82 to −3.98)	-0.23 (−0.27 to −0.18)		
	Model 2: Adjusted for demographic, health-related variables	Very drowsy	Reference category	Reference category	<.001	4.0%
		Moderately drowsy	-0.27 (−0.98 to 0.44)	-0.02 (−0.08 to 0.04)		
		Slightly drowsy	-1.17 (−1.85 to −0.50)	-0.15 (−0.24 to −0.07)		
		Fairly clearheaded	-1.82 (−2.49 to −1.15)	-0.27 (−0.37 to −0.17)		
		Alert	-2.59 (−3.28 to −1.90)	-0.31 (−0.39 to −0.23)		
		Very alert	-3.38 (−4.24 to −2.52)	-0.16 (−0.20 to −0.12)		

(*Continued*)

Table 3. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Satisfaction with sleep	Model 1: Unadjusted	Very unsatisfied	Reference category	Reference category	<.001	3.0%
		Moderately unsatisfied	-0.66 (−1.08 to −0.23)	-0.07 (−0.12 to −0.03)		
		Slightly unsatisfied	-0.95 (−1.35 to −0.55)	-0.12 (−0.17 to −0.07)		
		Fairly satisfied	-1.46 (−1.84 to −1.08)	-0.21 (−0.27 to −0.16)		
		Completely satisfied	-2.13 (−2.59 to −1.67)	-0.19 (−0.23 to −0.15)		
	Model 2: Adjusted for demographic, health-related variables	Very unsatisfied	Reference category	Reference category	<.001	1.0%
		Moderately unsatisfied	-0.19 (−0.58 to −0.20)	-0.02 (−0.06 to 0.02)		
		Slightly unsatisfied	-0.22 (−0.59 to 0.14)	-0.03 (−0.08 to 0.02)		
		Fairly satisfied	-0.48 (−0.84 to −0.13)	-0.07 (−0.12 to −0.02)		
		Completely satisfied	-1.04 (−1.48 to −0.61)	-0.09 (−0.13 to −0.05)		
Early awakening	Model 1: Unadjusted	Yes	0.82 (0.62 to 1.01)	0.12 (0.09 to 0.15)	<.001	1.0%
	Model 2: Adjusted for demographic, health-related variables	Yes	0.34 (0.17 to 0.54)	0.05 (0.03 to 0.08)	<.001	0.03%

(*Continued*)

Table 3. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Difficulty falling asleep	Model 1: Unadjusted	None or very little	Reference category	Reference category	<.001	2.0%
		Some	0.56 (0.34 to 0.78)	0.08 (0.05 to 0.10)		
		A lot	2.12 (1.64 to 2.59)	0.13 (0.10 to 0.16)		
		Extreme difficulty	1.69 (0.63 to 2.76)	0.05 (0.02 to 0.08)		
	Model 2: Adjusted for demographic, health-related variables	None or very little	Reference category	Reference category	<.001	1.0%
		Some	0.32 (0.13 to 0.52)	0.04 (0.02 to 0.07)		
		A lot	1.32 (0.88 to 1.76)	0.08 (0.05 to 0.11)		
		Extreme difficulty	0.12 (−0.86 to 1.10)	0.003 (−0.02 to 0.03)		
Depth of sleep	Model 1: Unadjusted	Very light	Reference category	Reference category	<.001	1.0%
		Light	-0.46 (−1.04 to 0.13)	-0.04 (−0.08 to 0.01)		
		Fairly light	-0.97 (−1.48 to −0.47)	-0.13 (−0.20 to −0.06)		
		Fairly deep	-1.18 (−1.68 to −0.69)	-0.17 (−0.25 to −0.10)		
		Deep	-1.54 (−2.09 to −0.98)	-0.14 (−0.19 to −0.09)		
		Very deep	-1.27 (−2.33 to −0.20)	-0.04 (−0.07 to −0.01)		
	Model 2: Adjusted for demographic, health-related variables	Very light	Reference category	Reference category	.208	0.003%
		Light	0.23 (−0.30 to 0.76)	0.02 (−0.02 to 0.06)		
		Fairly light	-0.15 (−0.61 to 0.31)	-0.02 (−0.08 to 0.04)		
		Fairly deep	-0.07 (−0.53 to 0.39)	-0.01 (−0.08 to 0.06)		
		Deep	-0.26 (−0.78 to 0.26)	-0.02 (−0.07 to 0.02)		
		Very deep	0.12 (−0.85 to 1.09)	0.004 (−0.03 to 0.03)		

(*Continued*)

Table 3. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Times awake during a night	Model 1: Unadjusted	One	Reference category	Reference category	<.001	0.2
		Two	0.42 (−0.15 to 0.98)	0.06 (−0.02 to 0.14)		
		Three	0.07 (0.40 to 1.53)	0.14 (0.06 to 0.22)		
		Four or more	1.44 (0.87 to 2.0)	0.20 (0.12 to 0.28)		
	Model 2: Adjusted for demographic and health-related variables	One	Reference category	Reference category	<.001	0.3%
		Two	0.16 (−0.35 to 0.68)	0.02 (−0.05 to 0.09)		
		Three	0.40 (−0.11 to 0.91)	0.06 (−0.02 to 0.13)		
		Four or more	0.63 (0.11 to 1.15)	0.09 (0.02 to 0.16)		
Hours of sleep during the night	Model 1: Unadjusted	Zero to five	Reference category	Reference category	<.001	1.0%
		Six to eight	-1.34 (−1.66 to −1.0)	-0.13 (−0.17 to −0.10)		
		Nine and above	-0.42 (−1.10 to 0.26)	-0.02 (−0.05 to 0.01)		
	Model 2: Adjusted for demographic and health-related variables	Zero to five	Reference category	Reference category	.275	0.02%
		Six to eight	-0.38 (−0.69 to −0.08)	-0.04 (−0.07 to −0.01)		
		Nine and above	0.27 (−0.35 to 0.89)	0.01 (−0.02 to 0.04)		
Hours of sleep during the day	Model 1: Unadjusted	Zero	Reference category	Reference category	<.001	1.0%
		One or two	1.85 (1.47 to 2.23)	0.15 (0.11 to 0.17)		
		Three or more	0.62 (−0.10 to 1.34)	0.02 (−0.004 to 0.05)		
	Model 2: Adjusted for demographic and health-related variables	Zero	Reference category	Reference category	<.001	0.4%
		One or two	(1) (0.69 to 1.38)	0.08 (0.05 to 0.11)		
		Three or more	0.35 (−0.30 to 1.0)	0.01 (−0.01 to 0.04)		

Demographic variables included in the model as covariates are age, sex, and education level. Health-related variables included in the model as covariates are depressive and anxiety symptoms and daily function. B – Regression coefficient. SE – Standard error. β – Standardized regression coefficient. 95% CI – 95% confidence interval.

Table 4. Linear regressions with participants' score on one of the nine indicators of sleep as the predictor and subjective age discrepancy at baseline as the outcome: Unadjusted and adjusted unstandardized and standardized regression coefficients and 95% confidence intervals.

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Quality of sleep	Model 1: Unadjusted	Very badly	Reference category	Reference category	<.001	1.0%
		Badly	0.05 (0.01 to 0.08)	0.08 (0.02 to 0.13)		
		Fairly badly	0.05 (0.02 to 0.08)	0.14 (0.06 to 0.22)		
		Fairly well	0.06 (0.03 to 0.08)	0.19 (0.10 to 0.29)		
		Well	0.06 (0.03 to 0.09)	0.17 (0.09 to 0.25)		
		Very well	0.08 (0.04 to 0.11)	0.12 (0.07 to 0.18)		
	Model 2: Adjusted for demographic and health-related variables	Very badly	Reference category	Reference category	.006	0.02%
		Badly	0.04 (0.01 to 0.07)	0.07 (0.01 to 0.12)		
		Fairly badly	0.04 (0.01 to 0.07)	0.11 (0.02 to 0.19)		
		Fairly well	0.04 (0.01 to 0.07)	0.14 (0.04 to 0.24)		
		Well	0.04 (0.01 to 0.07)	0.12 (0.04 to 0.20)		
		Very well	0.06 (0.02 to 0.09)	0.10 (0.04 to 0.15)		
Alertness after awakening	Model 1: Unadjusted	Very drowsy	Reference category	Reference category	<.001	1.0%
		Moderately drowsy	0.02 (−0.01 to 0.05)	0.04 (−0.03 to 0.10)		
		Slightly drowsy	0.03 (−0.001 to 0.06)	0.09 (−0.003 to 0.19)		
		Fairly clearheaded	0.03 (−0.001 to 0.06)	0.11 (−0.002 to 0.22)		
		Alert	0.05 (0.02 to 0.08)	0.13 (0.04 to 0.22)		
		Very alert	0.09 (0.05 to 0.13)	0.10 (0.06 to 0.15)		
	Model 2: Adjusted for demographic and health-related variables	Very drowsy	Reference category	Reference category	<.001	0.03%
		Moderately drowsy	(−0.02 to 0.04)	0.02 (−0.05 to 0.09)		
		Slightly drowsy	(−0.01 to 0.05)	0.05 (−0.05 to 0.15)		
		Fairly clearheaded	0.01 (−0.02 to 0.05)	0.05 (−0.06 to 0.16)		
		Alert	0.03 (−0.004 to 0.06)	0.08 (−0.01 to 0.17)		
		Very alert	0.08 (0.03 to 0.12)	0.08 (0.04 to 0.13)		

(*Continued*)

Table 4. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Satisfaction with sleep	Model 1: Unadjusted	Very unsatisfied	Reference category	Reference category	<.001	0.04%
		Moderately unsatisfied	-0.01 (−0.03 to 0.01)	-0.02 (−0.07 to 0.02)		
		Slightly unsatisfied	0.002 (−0.01 to 0.02)	0.01 (−0.04 to 0.06)		
		Fairly satisfied	0.02 (−0.0003 to 0.03)	0.06 (−0.001 to 0.11)		
		Completely satisfied	0.02 (0.001 to 0.04)	0.04 (0.002 to 0.09)		
	Model 2: Adjusted for demographic and health-related variables	Very unsatisfied	Reference category	Reference category	.010	0.01%
		Moderately unsatisfied	-0.01 (−0.03 to 0.004)	-0.04 (−0.08 to 0.01)		
		Slightly unsatisfied	-0.01 (−0.02 to 0.01)	-0.02 (−0.07 to 0.04)		
		Fairly satisfied	0.01 (−0.01 to 0.02)	0.02 (−0.04 to 0.08)		
		Completely satisfied	0.01 (−0.01 to 0.03)	0.02 (−0.03 to 0.06)		
Early awakening	Model 1: Unadjusted	Yes	−0.01 (−0.02 to 0.001)	−0.03 (−0.06 to 0.002)	.068	0.01%
	Model 2: Adjusted for demographic and health-related variables	Yes	−0.002 (−0.01 to 0.01)	−0.01 (−0.04 to 0.02)	.578	0.001%
Difficulty falling asleep	Model 1: Unadjusted	None or very little	Reference category	Reference category	.084	0.01%
		Some	-0.001 (−0.01 to 0.01)	-0.004 (−0.03 to 0.03)		
		A lot	-0.02 (−0.04 to −0.003)	-0.03 (−0.06 to −0.004)		
		Extreme difficulty	-0.02 (−0.06 to 0.03)	-0.01 (−0.04 to 0.02)		
	Model 2: Adjusted for demographic and health-related variables	None or very little	Reference category	Reference category	.948	0.001%
		Some	0.003 (−0.01 to 0.01)	0.01 (−0.02 to 0.04)		
		A lot	-0.01 (−0.03 to 0.01)	-0.02 (−0.05 to 0.01)		
		Extreme difficulty	0.01 (−0.04 to 0.05)	0.004 (−0.03 to 0.03)		

(*Continued*)

Table 4. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Depth of sleep	Model 1: Unadjusted	Very light	Reference category	Reference category	.001	0.03%
		Light	0.02 (−0.01 to 0.04)	0.03 (−0.01 to 0.08)		
		Fairly light	0.02 (−0.01 to 0.04)	0.05 (−0.02 to 0.12)		
		Fairly deep	0.02 (0.003 to 0.04)	0.08 (0.01 to 0.16)		
		Deep	0.03 (0.01 to 0.06)	0.07 (0.02 to 0.13)		
		Very deep	0.05 (0.01 to 0.10)	0.04 (0.01 to 0.07)		
	Model 2: Adjusted for demographic and health-related variables	Very light	Reference category	Reference category	.058	0.01%
		Light	0.01 (−0.01 to 0.03)	0.02 (−0.03 to 0.07)		
		Fairly light	0.01 (−0.01 to 0.03)	0.02 (−0.05 to 0.09)		
		Fairly deep	0.01 (−0.01 to 0.03)	0.04 (−0.04 to 0.11)		
		Deep	0.02 (−0.01 to 0.04)	0.04 (−0.01 to 0.09)		
		Very deep	0.04 (−0.01 to 0.08)	0.03 (−0.01 to 0.06)		
Times awake during a night	Model 1: Unadjusted	One	Reference category	Reference category	.002	0.02%
		Two	0.004 (−0.02 to 0.03)	0.01 (−0.07 to 0.09)		
		Three	-0.01 (−0.04 to 0.01)	-0.05 (−0.13 to 0.03)		
		Four or more	-0.02 (−0.04 to 0.01)	-0.06 (−0.13 to 0.02)		
	Model 2: Adjusted for demographic and health-related variables	One	Reference category	Reference category	.052	0.01%
		Two	0.004 (−0.02 to 0.03)	0.01 (−0.06 to 0.09)		
		Three	-0.01 (−0.03 to 0.01)	-0.04 (−0.12 to 0.04)		
		Four or more	-0.01 (−0.03 to 0.01)	-0.03 (−0.11 to 0.04)		
Hours of sleep during the night	Model 1: Unadjusted	Zero to five	Reference category	Reference category	.807	0.001%
		Six to eight	-0.004 (−0.02 to 0.01)	-0.01 (−0.04 to 0.02)		
		Nine and above	0.01 (−0.02 to 0.04)	0.01 (−0.02 to 0.05)		
	Model 2: Adjusted for demographic and health-related variables	Zero to five	Reference category	Reference category	.251	0.001%
		Six to eight	-0.01 (−0.03 to −0.001)	-0.04 (−0.07 to −0.003)		
		Nine and above	0.003 (−0.03 to 0.03)	0.004 (−0.03 to 0.04)		

(*Continued*)

Table 4. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Hours of sleep during the day	Model 1: Unadjusted	Zero	Reference category	Reference category	.268	0.003%
		One or two	-0.01 (−0.02 to 0.01)	-0.01 (−0.04 to 0.02)		
		Three or more	-0.01 (−0.04 to 0.02)	-0.01 (−0.04 to 0.02)		
	Model 2: Adjusted for demographic and health-related variables	Zero	Reference category	Reference category	.414	0.002%
		One or two	-0.0001 (−0.02 to 0.02)	-0.0002 (−0.03 to 0.03)		
		Three or more	-0.01 (−0.04 to 0.02)	-0.01 (−0.04 to 0.02)		

Demographic variables included in the model as covariates are age, sex, and education level. Health-related variables included in the model as covariates are depressive and anxiety symptoms and daily function. B = Regression coefficient. SE = Standard error. β = Standardized regression coefficient. 95%CI = 95% confidence interval.

calculated as the sum of the items, indicate more functional difficulties (range: 7–14). In this study Cronbach's α for the IADL was 0.77. More details on study measures can be found in Sabatini et al. (2020b).

Data analyses

To maximize use of the available data, mean imputation was used when a response for one of the nine items of the PHQ-9 was missing (this was done for 66 participants) and when a response for one of the seven items of the GAD-7 was missing (this was done for 15 participants).

We fitted linear regressions models to explore whether each of the nine indicators of subjective sleep difficulties (predictors) are related to levels of awareness of negative age-related change and subjective age (outcomes) measured concurrently and 1 year later. For each analysis, we fitted an unadjusted model and a second model adjusted for demographic variables (age, sex, and education), anxiety, depression, and daily function. We reported standardized regression coefficients (effects sizes) to quantify the associations, and considered values less than 0.1 as negligible, values between 0.1 and 0.3 as small, values between 0.3 and 0.5 as moderate, and values above 0.5 as large (Cohen, 1988).

Results

Sample characteristics

Sample characteristics are reported in Table 1. The mean (SD) age of the participants was 66.1 (6.9) years. Most of the participants were women (77.3%) and achieved university-level education (74%). On average, participants reported being "*a little bit*" aware of negative age-related change both at baseline (mean (SD) = 9.8 (3.2)) and at follow-up a year later (mean (SD) = 10.1 (3.4)) and felt 17% younger than their chronological age both at baseline (mean (SD; range) = 0.17 (0.1; −.48 to 0.99) and at follow-up (mean (SD; range) = 0.17 (0.1; −0.49 to 0.89). At baseline the majority of participants felt younger than their age (92.1%), 3.9% felt older (3.9%) than their chronological age and 4.0% felt their chronological age.

At baseline, nearly all participants (96.9%) perceived difficulties on at least one of the nine indicators examined. More specifically, 30.2% of participants rated their quality of sleep as bad, 35.2% reported feeling somehow drowsy at awakening, 48.2% of participants reported being somehow unsatisfied with their sleep, 44.0% reported early awakening, 35.0% reported at least some difficulty

Table 5. Linear regressions with participants' score on one of the nine indicators of sleep as the predictor and subjective age discrepancy at follow-up as the outcome: Unadjusted and adjusted unstandardized and standardized regression coefficients and 95% confidence intervals.

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Quality of sleep	Model 1: Unadjusted	Very badly	Reference category	Reference category	<.001	0.04%
		Badly	0.01 (−0.02 to 0.04)	0.02 (−0.03 to 0.07		
		Fairly badly	0.02 (−0.01 to 0.05)	0.07 (−0.02 to 0.15)		
		Fairly well	0.03 (0.001 to 0.05)	0.10 (0.003 to 0.20)		
		Well	0.04 (0.01 to 0.07)	0.11 (0.03 to 0.19)		
		Very well	0.05 (0.02 to 0.08)	0.08 (0.03 to 0.13)		
	Model 2: Adjusted for demographic, health-related variables	Very badly	Reference category	Reference category	<.001	0.01%
		Badly	0.004 (−0.03 to 0.03)	0.01 (−0.05 to 0.0)		
		Fairly badly	0.01 (−0.02 to 0.04)	0.03 (−0.05 to 0.12)		
		Fairly well	0.01 (−0.02 to 0.04)	0.04 (−0.06 o 0.14)		
		Well	0.02 (−0.01 to 0.05)	0.05 (−0.03 to 0.13)		
		Very well	0.03 (−0.01 to 0.06)	0.04 (−0.01 to 0.10)		
Alertness after awakening	Model 1: Unadjusted	Very drowsy	Reference category	Reference category	<.001	1.0%
		Moderately drowsy	0.02(−0.02 to 0.05)	0.03 (−0.04 to 0.10)		
		Slightly drowsy	0.02 (−0.01 to 0.05)	0.07 (−0.03 to 0.17)		
		Fairly clearheaded	0.03 (−0.001 to 0.06)	0.11 (−0.003 to 0.21)		
		Alert	0.04 (0.01 to 0.07)	0.11 (0.02 to 0.20)		
		Very alert	0.08 (0.04 to 0.12)	0.10 (0.05 to 0.14)		
	Model 2: Adjusted for demographic, health-related variables	Very drowsy	Reference category	Reference category	.003	0.02%
		Moderately drowsy	0.01 (−0.03 to 0.04)	0.01 (−0.05 to 0.08)		
		Slightly drowsy	0.01 (−0.02 to 0.04)	0.03 (−0.07 to 0.13)		
		Fairly clearheaded	0.01 (−0.02 to 0.04)	0.04 (−0.07 to 0.15)		
		Alert	0.02 (−0.01 to 0.05)	0.05 (−0.04 to 0.15)		
		Very alert	0.06 (0.02 to 0.10)	0.07 (0.03 to 0.12)		

(*Continued*)

Table 5. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Satisfaction with sleep	Model 1: Unadjusted	Very unsatisfied	Reference category	Reference category	<.001	0.05%
		Moderately unsatisfied	0.001 (−0.02 to 0.02)	0.003 (−0.04 to 0.05)		
		Slightly unsatisfied	0.001 (−0.02 to 0.02)	0.003 (−0.05 to 0.05)		
		Fairly satisfied	0.02 (0.003 to 0.03)	0.07 (0.01 to 0.12)		
		Completely satisfied	0.03 (0.01 to 0.05)	0.06 (0.02 to 0.11)		
	Model 2: Adjusted for demographic, health-related variables	Very unsatisfied	Reference category	Reference category	.016	0.01%
		Moderately unsatisfied	-0.003 (−0.02 to 0.01)	-0.01 (−0.06 to 0.04)		
		Slightly unsatisfied	-0.01 (−0.02 to 0.01)	-0.02 (−0.07 to 0.03)		
		Fairly satisfied	0.01 (−0.01 to 0.02)	0.02 (−0.03 to 0.08)		
		Completely satisfied	0.01 (−0.01 to 0.03)	0.03 (−0.01 to 0.08)		
Early awakening	Model 1: Unadjusted	Yes	−0.01 (−0.02 to −0.002)	−0.04 (−0.07 to −0.01)	.013	0.01%
	Model 2: Adjusted for demographic, health-related variables	Yes	−0.004 (−0.01 to 0.004)	−0.01 (−0.04 to 0.02)	.365	0.002%
Difficulty falling asleep	Model 1: Unadjusted	None or very little	Reference category	Reference category	.028	0.01%
		Some	-0.004 (−0.01 to 0.01)	-0.01 (−0.04 to 0.02)		
		A lot	-0.03 (−0.05 to −0.019	-0.04 (−0.07 to −0.01)		
		Extreme difficulty	−0.001 (−0.04 to 0.04)	-0.001 (−0.03 to 0.03)		
	Model 2: Adjusted for demographic, health-related variables	None or very little	Reference category	Reference category	.584	0.001%
		Some	0.0001 (−0.01 to 0.01)	0.0004 (−0.03 to 0.03)		
		A lot	-0.02 (−0.04 to 0.003)	-0.03 (−0.06 to 0.004)		
		Extreme difficulty	0.02 (−0.02 to 0.07)	0.01 (−0.02 to 0.04)		

(*Continued*)

Table 5. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Depth of sleep	Model 1: Unadjusted	Very light	Reference category	Reference category	.003	0.02%
		Light	0.01 (−0.01 to 0.03)	0.02 (−0.03 to 0.07)		
		Fairly light	0.01 (−0.01 to 0.03)	0.04 (−0.03 to 0.11)		
		Fairly deep	0.02 (−0.003 to 0.04)	0.06 (−0.01 to 0.14)		
		Deep	0.03 (0.01 to 0.05)	0.07 (0.02 to 0.12)		
		Very deep	0.03 (−0.01 to 0.08)	0.02 (−0.02 to 0.06)		
	Model 2: Adjusted for demographic, health-related variables	Very light	Reference category	Reference category	.248	0.003%
		Light	0.003 (−0.02 to 0.03)	0.01 (−0.04 to 0.05)		
		Fairly light	0.002 (−0.02 to 0.02)	0.01 (−0.07 to 0.08)		
		Fairly deep	0.002 (−0.02 to 0.02)	0.01 (−0.07 to 0.08)		
		Deep	0.01 (−0.01 to 0.04)	0.03 (−0.02 to 0.08)		
		Very deep	0.02 (−0.03 to 0.06)	0.01 (−0.02 to 0.04)		
Times awake during a night	Model 1: Unadjusted	One	Reference category	Reference category	.001	0.02%
		Two	-0.01 (−0.04 to 0.01)	-0.04 (−0.12 to 0.03)		
		Three	-0.02 (−0.05 to −0.001)	-0.08 (−0.16 to −0.004)		
		Four or more	-0.03 (−0.06 to −0.01)	-0.11 (−0.19 to −0.04)		
	Model 2: Adjusted for demographic, health-related variables	One	Reference category	Reference category	.045	0.01%
		Two	-0.01 (−0.03 to 0.01)	-0.04 (−0.12 to 0.04)		
		Three	-0.02 (−0.04 to 0.003)	-0.07 (−0.15 to 0.01)		
		Four or more	-0.03 (−0.05 to −0.003)	-0.09 (−0.17 to −0.01)		
Hours of sleep during the night	Model 1: Unadjusted	Zero to five	Reference category	Reference category	.685	0.0%
		Six to eight	-0-001 (−0.01 to 0.01)	-0.003 (−0.04 to 0.03)		
		Nine and above	0.01 (−0.02 to 0.03)	0.01 (−0.03 to 0.04)		
	Model 2: Adjusted for demographic, health-related variables	Zero to five	Reference category	Reference category	.042	0.01%
		Six to eight	-0.01 (−0.03 to 0.001)	-0.03 (−0.06 to 0.002)		
		Nine and above	-0.004 (−0.03 to 0.02)	-0.01 (−0.04 to 0.03)		

(*Continued*)

Table 5. (Continued).

Variables			B (95% CI)	β (95% CI)	*p*-value	Total R^2/ Partial R^2
Hours of sleep during the day	Model 1: Unadjusted	Zero	Reference category	Reference category	.855	0.0%
		One or two	-0.01 (−0.03 to 0.003)	-0.02 (−0.05 to 0.01)		
		Three or more	0.01 (−0.02 to 0.04)	0.01 (−0.02 to 0.04)		
	Model 2: Adjusted for demographic, health-related variables	Zero	Reference category	Reference category	.950	0.0%
		One or two	-0.01 (−0.02 to 0.01)	-0.01 (−0.04 to 0.02)		
		Three or more	0.01 (−0.02 to 0.04)	0.01 (−0.02 to 0.04)		

Demographic variables included in the model as covariates are age, sex, and education level. Health-related variables included in the model as covariates are depressive and anxiety symptoms and daily function. B = Regression coefficient. SE = Standard error. β = Standardized regression coefficient. 95%CI = 95% confidence interval.

falling asleep, and 43.5% rated the depth of their sleep as being light. A considerable proportion of participants reported waking two (31.6%), three (34.4%), or four or more (30.8%) times during the night. Most participants (86.9%) reported sleeping between six and eight hours per night and most participants (91.1%) did not sleep during the day. Participants reported minimal depression and anxiety and good daily function at baseline.

Subjective sleep difficulties as predictors of awareness of negative age-related change

Tables 2 and 3 report the coefficients from the linear regression models examining the cross-sectional and longitudinal associations of the nine indicators of subjective sleep difficulties with awareness of negative age-related change. Overall, a poorer quality of sleep (*p*-value <.001; coefficient of determination (R^2) = 3.0%), being less alert after awakening (*p*-value <.001; R^2 = 8.0%), being less satisfied with one's sleep (*p*-value <.001; R^2 = 3.0%), awakening early in the morning (*p*-value <.001; R^2 = 2.0%), having more difficulty falling asleep (*p*-value <.001; R^2 = 2.0%), having less deep sleep (*p*-value <.001; R^2 = 1.0%), more times awake during a night (*p*-value <.001; R^2 = 0.2%), sleeping less than six hours or more than eight hours during the night (*p*-value <.001; R^2 = 2.0%), and sleeping during the day (*p*-value <.001; R^2 = 1.0%), were associated with higher awareness of negative age-related change at baseline. Except for depth of sleep (*p*-value = .08), associations between the remaining indicators of subjective sleep difficulties and awareness of negative age-related change remained statistically significant after adjusting for covariates.

Results show that, although less deep sleep was associated with higher awareness of negative age-related change, poorer scores in depth of sleep were not constantly associated with higher levels of awareness of negative age-related change. However, the strength of the association between awareness of negative age-related change and depth of sleep was negligible. Higher awareness of negative age-related change was associated with more frequent awakening during the night. However, individuals awakening on average two times during the night reported less awareness of negative age-related change than those awakening once during the night whereas individuals awakening three times during the night or four times or more times during the night reported greater awareness of negative age-related change. However, for this association the effect sizes were very small.

Similarly, a poorer quality of sleep (*p*-value <.001; R^2 = 2.0%), being less alert after awakening (*p*-value <.001; R^2 = 8.0%), being less satisfied with one's sleep (*p*-value <.001; R^2 = 3.0%), awakening early in the morning (*p*-value <.001; R^2 = 1.0%), having more difficulty falling asleep (*p*-value <.001; R^2 = 2.0%), having less deep sleep (*p*- value <.001; R^2 = 1.0%), more times awake during a night (*p*-

value <.001; R^2 = 1.0%), sleeping less than six hours or more than eight hours during the night (*p*-value <.001; R^2 = 1.0%), and sleeping during the day (*p*-value <.001; R^2 = 1.0%), were associated with higher awareness of negative age-related change at follow-up a year later. Except for depth of sleep and hours of sleep during the night, associations between the above indicators of subjective sleep difficulties and awareness of negative age-related change at follow-up remained statistically significant after adjusting for covariates. Overall, associations were of either small or negligible size.

Subjective sleep difficulties as predictors of subjective age

Tables 4 and 5 report the coefficients from the linear regression models examining relationships of the nine indicators of subjective sleep difficulties with the percentage discrepancy score for subjective age. Before adjusting for covariates, a poorer quality of sleep (*p*-value <.001; R^2 = 1.0%), being less alert after awakening (*p*-value <.001; R^2 = 1.0%), being less satisfied with one's sleep (*p*-value <.001; R^2 = 0.04%), having less deep sleep (*p*-value = .001; R^2 = 0.03%), and awakening more times during the night (*p*-value = .002; R^2 = 0.02%) were associated with a smaller positive discrepancy score between one's age and one's felt age at baseline, indicating that individuals with more negative scores in these subjective sleep indicators felt less younger than their chronological age. After adjusting for covariates, the associations for depth of sleep (*p*-value = .06) and hours of sleep during the night (*p*-value = .81) with subjective age discrepancy score became weaker. Early awakening (*p*-value = .07), difficulty falling asleep (*p*-value = .08), hours of sleep during the night (*p*-value = .81), and hours of sleep during the day (*p*-value = .27) were not significantly associated with subjective age discrepancy score at baseline.

Before adjusting for covariates a poorer quality of sleep (*p*-value <.001; R^2 = 0.04%), being less alert after awakening (*p*-value <.001; R^2 = 1.0%), being less satisfied with one's sleep (*p*-value <.001; R^2 = 0.05%), awakening early in the morning (*p*-value = .013; R^2 = 0.01%), more difficulty falling asleep (*p*-value = .028; R^2 = 0.01%), having less deep sleep (*p*-value = .001; R^2 = 0.03%), and awakening more frequently during the night (*p*-value = .001; R^2 = 0.02%) were associated with a smaller positive discrepancy score between one's age and one's felt age at follow-up (younger subjective age to a lower extent). However, these associations were of small size; the associations of early awakening (*p*-value = .37), difficulty falling asleep (*p*-value = .58), and dept of sleep (*p*-value = .25) with subjective age discrepancy score became particularly weaker after adjusting for covariates.

The association between fewer hours of sleep during the night and a smaller positive subjective age discrepancy score – indicating a younger subjective age to a greater extent – was not statistically significant before adjusting for covariates (*p*-value = .69) but it became slightly stronger after adjusting for covariates (*p*-value = .042; R^2 = 0.01%). Hours of sleep during the day were not significantly associated with subjective age discrepancy score at follow-up (*p*-value = .27).

Discussion

This study explored for the first time the cross-sectional and longitudinal associations of nine indicators of subjective sleep difficulties with awareness of negative age-related change and subjective age in a large sample of UK individuals aged 50 and over. We confirmed our hypotheses that those individuals with more severe subjective sleep difficulties would report more awareness of negative age-related change and would feel older than their chronological age to a greater extent, both concurrently and one-year later, and that associations would have been stronger for awareness of negative age-related change than for subjective age. Study results suggest that those individuals experiencing sleep difficulties are at higher risk of negative self-perceptions of aging.

Although we found that more severe subjective sleep difficulties predict more negative self-perceptions of aging, it may be that more negative self-perceptions of aging also predict more negative evaluations of one's sleep (Stephan et al., 2017). The potential bidirectional association between subjective sleep difficulties and self-perceptions of aging should be tested in future research. Future

studies could also investigate whether both subjective sleep difficulties and negative self-perceptions of aging are the consequence of other factors such as physical decline (Barnett et al., 2012; Royall et al., 2007; Zee & Turek, 2006).

Before adjusting for covariates, the associations of subjective sleep difficulties with subjective age were either negligible or not statistically significant. Similarly, the association between severity of subjective sleep difficulties and subjective age was found to be statistically significant but negligible in three cohort studies (Midlife in the United States survey; Health and Retirement Study; National Health and Aging Trends Study) of American older adults (Stephan et al., 2017). The stronger association we found between subjective sleep difficulties and awareness of negative age-related change compared to that between subjective sleep difficulties and subjective age are consistent with previous evidence (Brothers et al., 2017; Sabatini et al., 2021b). This may be due to awareness of age-related change capturing negative age-related changes in those domains that are generally associated with poorer sleep (Sabatini et al., 2020a, 2020b, 2021b, 2020c).

Among the nine indicators of subjective sleep difficulties that we explored, perceived alertness after awakening showed the strongest association with awareness of negative age-related change. The negative impact of sleep fragmentation on people's functioning (e.g., cognitive functioning) is well reported (Yaffe et al., 2014). It may be that due to few hours of sleep at night, non-restful sleep, and perceived lack of alertness, individuals limit their engagement in social and health-related activities and, as a consequence, they are increasingly aware of negative age-related change (Brassington & Hicks, 1995; Freburger et al., 2010; Holfeld & Ruthig, 2014).

The predictive role of most indicators of subjective sleep difficulties over awareness of negative age-related change became negligible after adjusting for mood and daily function. As the covariates explained a bigger amount of variance in levels of awareness of negative age-related change than subjective sleep difficulties, it may be that individuals with more subjective sleep difficulties perceive more age-related losses mainly due to their concomitant poor mood and daily functioning. Nonetheless, as subjective sleep difficulties explained an additional yet small amount of variability in awareness of negative age-related change, they may be one of the many antecedents of awareness of negative age-related change. This finding is in line with the conceptual framework of awareness of age-related change hypothesizing a wide range of health-related predictors of awareness of age-related change (Diehl & Wahl, 2010).

The finding that individuals awakening two or three times during the night report less awareness of negative age-related change compared to those awakening one time during the night was unexpected; as this association was of negligible size, before attempting any interpretation our results need to be replicated with further research. Moreover, due to lack of data on the reasons why participants awake during the night, any interpretation would be speculative.

Overall, individuals with more severe subjective sleep difficulties, and particularly those not feeling alert at awakening, may be at higher risk of experiencing greater awareness of negative age-related change over time. Treatment of sleep difficulties in middle and older age may, therefore, be an additional important element to target, alongside poor mood and poor daily functioning, when promoting better quality of life and more positive experiences of aging. Promoting more positive experiences of aging is important as these are related to higher engagement in health-related and adaptive behaviors and, as a consequence, to better health and wellbeing in older age (Brothers & Diehl, 2017; Brothers et al., 2020; Kaspar et al., 2021; Wilton-Harding & Windsor, 2021). Individuals with subjective sleep difficulties may also benefit from intervention programs facilitating adaptation to changes in sleep and in daily functioning and more positive mood and self-perceptions of aging (Beyer et al., 2019; Brothers & Diehl, 2017; Burnes et al., 2019; Collins & Kishita, 2018; Klusmann et al., 2012; Vailati Riboni et al., 2020).

Strengths and limitations

The present study has several limitations. First, generalization of study results to the broader population may be limited due to the large proportion of women and well-educated participants (Ackerman & Chopik, 2020). Indeed, generally women report less awareness of negative age-related change and more subjective sleep difficulties, whereas better-educated individuals report less awareness of negative age-related change and fewer subjective sleep difficulties (Leng et al., 2014; Sabatini et al., 2020b). Second, 2,776 individuals were excluded from analyses as they did not complete all study measures at follow-up. Even though these individuals showed similar demographic characteristics to the analysis sample, the latter may include individuals more interested in subjective sleep and age-related experiences. Third, even though co-morbidity is associated with poorer sleep (Foley et al., 2010) and older age (Public Health England, 2018), we did not adjust for co-morbidity as this variable was not available in the PROTECT dataset. Hence, it was not possible to explore whether both poor sleep and high awareness of negative age-related change are due to the underlying presence of illnesses.

Fourth, as we measured subjective sleep difficulties over the past month, we could not investigate whether the strength of the association of awareness of age-related change with subjective sleep difficulties depends on the duration of subjective sleep difficulties. Exploring this would have been important as individuals experiencing subjective sleep difficulties for longer time may be more aware of negative age-related change. Fifth, as subjective sleep difficulties, awareness of age-related change, and subjective age all rely on individuals' perceptions, they may be capturing overlapping constructs such as levels of introspection, explaining why we found significant associations among these concepts. Sixth, although participants with pathological cognitive decline may experience higher levels of awareness of negative age-related changes, we did not exclude from the current study sample those participants with mild cognitive impairment. This is because only 21 participants self-reported a diagnosis of mild cognitive impairment and none reported a diagnosis of dementia; it is therefore unlikely that participants' cognitive status affected study results.

The large sample size, the use of a multidimensional measure of awareness of age-related change valid in the UK, and the longitudinal study design made it possible to reliably explore the stability of the association between subjective sleep difficulties and self-perceptions of aging over time. As many studies have explored the association of subjective sleep difficulties with mood and daily function among clinical cohorts, exploring subjective sleep difficulties in a community cohort adds new contributions to sleep literature (Gadie et al., 2017).

Conclusions

Overall, subjective sleep difficulties may be one of the many factors that, alongside poorer mood and daily functioning, is associated with awareness of negative age-related change. Individuals with more severe subjective sleep difficulties, especially those reporting poorer alertness after awakening, may be more vulnerable to the experience of awareness of negative age-related change. Treating sleep problems in middle and older age may, therefore, make a small contribution to the promotion of better experiences of aging.

As awareness of age-related change was more strongly related to subjective sleep difficulties compared to subjective age, future studies examining the associations of self-perceptions of aging with subjective sleep difficulties may want to assess awareness of age-related change as an indicator of self-perceptions of aging.

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Data access statement

PROTECT data are available to investigators outside the PROTECT team after request and approval by the PROTECT Steering Committee. Data for the AARC-10 SF questionnaire will be available from May 2022.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Author contribution

S S served as principal investigator of the research, designed the study, conducted data analyses, and took the lead in writing the manuscript.

L C contributed to the design of the study, analyses of data, and writing the manuscript.

O U contributed to analyses of data and writing the manuscript.

A C, H B, and C B contributed to data collection and design of the PROTECT study, and provided feedback on the draft of the manuscript.

R C provided feedback on the draft of the manuscript.

Supplementry material

Supplemental data for this article can be accesed on the publishere's

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